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Repairing Infrastructures

The Maintenance of Materiality and Power

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2 Cold Offices and Hot Airplanes: Local Negotiations over Repair

The Cold Office Problem

An office administrator makes a call to the maintenance center at the university where she works. Her complaint? The office is too cold, and could someone check out the problem for her? When the mechanic arrives to investigate the office's ventilation system, he finds that there is "no problem"—the office temperature and the rate of airflow through the office vents are within the range of normal expected for that building and day. While the mechanic used instruments and flashing numbers to convince the office worker that her workplace was not in need of repair, she still felt cold and was frustrated by the lack of a straightforward fix for her complaint.

This brief encounter, taken from Henke's research with a group of university-based physical plant mechanics, describes what we term the "cold office problem" and is likely a common situation for workers in offices all around the world (especially where temperature control—or even opening a window—is not at the discretion of the workers inhabiting the office space). The cold office problem raises a lot of interesting questions about repair. How do we really know when something is broken? Who gets to decide if something needs to be fixed, the best approach for fixing it, and the criteria for deciding when a fix is complete? What happens when people disagree about repair? Does the status or identity of the persons involved shift the process of mending things? Not all cases of repair involve these kinds of questions, but they are the ones that interest us here, and they also tend to be pretty common. Anyone who has taken in their car for service, who has been to the doctor to have a bodily complaint checked

out—or, indeed, anyone who has complained that a room is too cold or too hot—knows that repair can be messy. We usually hope for an easy diagnosis and fix, but it does not always work that way.

In this chapter, we explore the ways that repair is negotiated: subject to conversations, power struggles, and trial-and-error experimentation that shape the process and outcomes of repair work. Our focus here is on the local scale of repair, where hidden infrastructures like office heating and cooling systems intersect with our everyday routines. If repair is negotiated between people and the material stuff that surrounds them, then beginning at this local level of analysis provides a foundation for the coming chapters that examine infrastructure and repair at larger scales.

Exploring repair at the local scale helps us see how infrastructures are negotiated through two elements of the conceptual tool kit we introduced in chapter 1: *materiality and discourse* and *power and invisibility*. The cold office problem illustrates each of these concepts and their connections. Air, duct work, tools, and workers' bodies provide a material basis for the action in this work setting, but at the same time, it is the exchange of cultural meanings and frames through language that allows the two office workers to negotiate whether a room's temperature should be treated as normal or somehow in need of repair.

These interactions both reinforce and are supported by power relations that shape the interactions among various people and things. The cold office problem features a mechanic who has the power to control aspects of the ventilation system for which the office worker is not allowed access. Although the office worker may have access to other sources of power and influence, her lack of control over the air-conditioning system limits her ability to influence the outcome of this particular repair process. It is also important to emphasize that the mechanics at this university are overwhelmingly men, while most of the office administrators are women; the gendering of repair work, and its consequences for repair outcomes, is a topic we return to later in this chapter.

Negotiated repair, then, never takes place in a vacuum. The interactions surrounding it are heavily influenced by preexisting social hierarchies and power relations. This means that some people ultimately have more visibility and influence over repair processes and outcomes than others, though the question of who wields power and who becomes marginalized or invisible is not always easily resolved. An office administrator may have access

to organizational decision makers who have influence over hiring and firing of maintenance workers, for example, and in general people who are excluded from certain kinds of power may find alternative ways of exercising control.

Defining and Controlling Thermal Comfort

How is temperature controlled in an office environment? And who gets to set it?

Building engineers have been working on answers to these questions over the past half-century, and one name stands out in the academic literature and engineering practices on thermal comfort in buildings. The Fanger thermal comfort model was developed in the 1960s by Danish engineer Povel Ole Fanger, who performed a number of experiments on human subjects in climate chambers to assess perceived comfort on a seven-point scale (figure 2.1). Correlation of measures such as temperature and airflow with the subjective reports of comfort from test subjects allowed Fanger and colleagues to determine a zone of comfort where the “predicted mean vote” of participants who would likely feel too warm or too cool could be minimized.¹ Fanger’s 1973 article, “Assessment of Man’s Thermal Comfort in Practice,” outlines a number of criteria that can have an impact on feelings of comfort, such as the type of clothing worn (or “clo-units,” ranging from naked [0 clo-units], to bikinis [.05 clo-units], to business suits [1 clo-unit]), age, type of environment in which a person was raised, and gender. Fanger included equal numbers of men and women in his experiments and found they “seem to prefer almost the same thermal environments.”²

Essentially, the Fanger model tries to balance out the thermal preferences of a group of people, and more recent work debates whether this compromise is an appropriate way to set temperature. Neutral values are not always consistent, even from the same person on a day-to-day basis, and may vary in many ways, including seasonally, cross-culturally, and between laboratory and field studies.³ A letter published in *Nature Climate Change* in 2015 challenged one key aspect of the Fanger model, the metabolic rates of men and women, claiming that the model may overestimate female metabolisms and thus provide temperature settings too low for women. A report on this study in the *New York Times* featured several stories of women who wore heavy sweaters and blankets when working in their office spaces.⁴

This question of how temperature is set is related to but also different from the question of control: Who has control over the systems that provide cooling and heating to a particular building and its living and working spaces? On this point, Fanger and his more recent critics agree: models of thermal comfort work best when their subjects have some discretion over temperature.⁵

Defining and Controlling Thermal Comfort (continued)

In the office building where Henke works, employees do not have direct control over the temperature in their offices; each office has a sensor on the wall that reports air temperature back to a central control system. Those who feel that their office is too cold often place a chilled, damp paper towel over the climate sensor on their wall, to trick the system into pumping out more heat (figure 2.2). It works, giving them partial discretion over a system that is controlled elsewhere on the campus. The paper towel trick illustrates how negotiations between people and things, and technologies and institutions, lead to complexity and fluidity in repair. Order and change, normal and broken, depend in part on one's perspective.

1 P. O. Fanger, *Thermal Comfort: Analysis and Applications in Environmental Engineering* (Copenhagen: Danish Technical Press, 1970).

2 P. O. Fanger, "Assessment of Man's Thermal Comfort in Practice," *British Journal of Industrial Medicine* 30 (1973): 320; Fanger, *Thermal Comfort*, 86–87.

3 J. van Hoof, "Forty Years of Fanger's Model of Thermal Comfort: Comfort for All?" *Indoor Air* 18, no. 3 (2008): 182–201; Liu Yang, Haiyan Yan, and Joseph C. Lam, "Thermal Comfort and Building Energy Consumption Implications—a Review," *Applied Energy* 115 (2014): 164–173.

4 Boris Kingma and Wouter van Marken Lichtenbelt, "Energy Consumption in Buildings and Female Thermal Demand," *Nature Climate Change* 5 (2015): 1054–1056; Pam Belluck, "Chilly at Work? Office Formula Was Devised for Men," *New York Times*, August 3, 2015, <https://www.nytimes.com/2015/08/04/science/chilly-at-work-a-decades-old-formula-may-be-to-blame.html>; S. Karjalainen, "Thermal Comfort and Gender: A Literature Review," *Indoor Air* 22, no. 2 (2012): 96–109; Caroline Criado Perez, *Invisible Women: Data Bias in a World Designed for Men* (New York: Abrams Press, 2019).

5 Fanger, "Assessment of Man's Thermal Comfort in Practice," 313; van Hoof, "Forty Years of Fanger's Model of Thermal Comfort," 182.

At the heart of local repair are human bodies, the material world they inhabit and interact with, and the negotiations among the people, tools, and infrastructures that define the boundaries of repair encounters. The cold office problem, for example, concerns two workers in a specific, material setting—the office and its surrounding infrastructure—and how they negotiate definitions of breakdown and repair based on the sensations and experiences internalized in their bodies and the politics of their own identities and roles.



Figure 2.1

An image from one of Fanger's climate chamber studies, captioned: "Subjects wearing a standard uniform (0.6 clo) during thermal studies in the environmental test chamber at the Technical University of Denmark. During the studies, physical and physiological measurements are correlated with the subjective evaluations of the subjects." Reproduced from P. O. Fanger, "Assessment of Man's Thermal Comfort in Practice," *British Journal of Industrial Medicine* 30 (1973): 319. With permission from BMJ Publishing Group Ltd.



Figure 2.2

The paper towel trick in use. Photograph by Christopher R. Henke, 2018.

In this chapter, we examine several aspects of local repair negotiations. First, we explore the importance of the body and its networked connections to the material world of infrastructure. Next, we look at the connection between materiality and discourse by examining talk about repair and how these conversations serve to negotiate repair in everyday work settings. Talking about repair defines the boundaries of repair communities, as well as the disagreements and conflicting interests that make up the local politics of repair. Finally, we discuss the role of difference in repair, especially the gendering of care and emotional labor, which influences our views about who does what kind of repair and how they ought to do it. Following these differences leads us into further discussion of the role of power and invisibility in repair.

Infrastructures as Local Structures: Bodies and Materiality

A cold office is a local problem. A worker who rubs her hands and arms to warm up feels in her very bones that something is not right with the temperature in her office. This interface of bodies and the material environment they inhabit is a good place to start understanding how repair plays out on a local scale. In later chapters, we examine how infrastructures increasingly stretch around the world and connect us in myriad ways to global systems of communication, travel, and ecological change. Despite this global reach, we typically interact with infrastructures in a very local way. When our car hits a pothole in the road or tainted hamburger meat makes us sick, we feel these events most directly as a jolt to the body, even though the conditions that led to these events are connected to broader technological and political systems.

There is an immediacy and sensual connection in our local relationships with infrastructures that has important consequences for how we understand and act through them. That bodily connection in turn provides an important context for repair, shaping how we identify and negotiate the need for it and our preferred solutions. There are aspects of infrastructure and repair we come to know through our local connections to them that we cannot access or understand in the same way from a distance. So the local work of repair is defined in part by proximity: repair of specific systems, in particular places, accomplished by people working alone or closely together, interacting and engaging with a broken machine or facility. But

the materiality of this engagement is also crucial. The stuff we hold to hand and bump against provides us with both abilities and constraints that shape and delimit our actions.

Sociologist Tim Dant describes this relationship as “material interaction,” which is a subtle way to describe a profound condition.¹ We exist in a material context, and if that seems obvious, that is in part because social scientists have sometimes eschewed the material in favor of placing more weight on dematerialized “social” explanations.² Human actors design infrastructures in specific ways and for specific purposes. Using examples from his work on automobiles and their repair, Dant describes a threaded nut and bolt as “[artifacts that] embody the intentional actions of prior human beings,” thereby building meanings and uses right into the form and structure of these objects.³ In this way, people invest materiality with specific intentions and interests, and those designs inform the actions of other users. As a result, when a mechanic needs to repair a broken nut or bolt, a range of options may be possible, but a replacement of the same size and type of part is likely the most straightforward repair. The broken bolt might be repurposed for another use—even as a piece of art—but the shape and structure of the artifact suggest a specific use. Some scholars of materiality go a step further, emphasizing the ability of so-called nonhuman entities such as other organisms or things to act in ways that might either parallel our own interests and actions or resist them.⁴ This nonhuman agency can also be seen as a more passive kind of push or pull, as in Bruno Latour’s example of a speed bump, a feature of a roadway that forces drivers to slow down by design, thereby acting on drivers and their intention to speed along without delay.⁵

Latour claims that materiality represents the “missing masses” that are required to give a complete picture of the connections among nature, technology, and human actions and relationships. Materiality is “missing” because it is so ubiquitous that we sometimes do not fully acknowledge its significance.⁶ This materialist perspective leaves some questions about the relationship between human and material agency. As the cold office problem demonstrates, people can, and often do, have very different perspectives about the state of material infrastructures.

How can materiality be both a hard set of constraints and something we interpret and act on in flexible ways? We suggest that repair is one of the missing practices that enable us to resolve this tension by negotiating

how the social and the material come together in specific places, with human bodies as the crucial link between the two. Local interactions with infrastructures involve repair on a continuous basis, in ways big and small, and the material configuration of infrastructures suggests possible ways of approaching repair when breakdowns occur. For example, if we are having car trouble, the hood of the car provides a natural point of access to the engine, and a modern engine itself incorporates visual cues on how to interact with it that even people without mechanical skills can understand: colored lids to unscrew, dipsticks to pull out, and markings showing acceptable fluid levels. These structures reflect human designs and interests, however, and we may interpret them in disparate ways. An engine provides more and different points of access to an experienced mechanic, who consequently may see very different possibilities for repair than a naive consumer does. Even with their differential expertise, mechanics and car owners may have legitimate disagreements on what kind of repair is necessary—or what a reasonable cost for repair is. This is where seeing repair as a practice of negotiation, between human actors as well as between people and things, helps visualize the ongoing and messy process of working within local contexts of infrastructure and culture.

Consider another example from Henke's work with the building mechanics: a maintenance worker named Al is dispatched to the campus teaching hospital, where the staff are concerned about a burning smell in their surgical ward. The following field notes describe how Al, using his bodily senses, works through the materiality of the hospital's infrastructure as he seeks the source of the trouble:

Al and I respond to a complaint from the medical clinic that there's "a burning smell" near a surgery area. Upon arriving at the scene of the complaint, we can immediately smell the odor as well. The scent is strongest in a hallway just between the reception area and patient recovery room.

Al remarks that the odor smells like a burnt-out ballast—an electrical part of the fluorescent light. Are any lights not working? No, all the lights in this hall area seem to be lit.

Al sets up [a] ladder in the hallway and removes a panel of the white foam ceiling, poking his head above and sniffing. "The scent's not so strong above the ceiling," Al says. "It might be coming from this vent duct."

There is a duct for a ventilation shaft that comes down and ends in a screen in the ceiling, very close to where Al has just sampled the air with his nose. Is the odor coming from the shaft?

The shaft [leads to] an air handling unit on the roof of the building, a device which passes air over hot or cool water—depending on whether the building needs to be heated or cooled. Al and I go to the roof. The air handler is the size of a comfortable office. He opens a door on the unit and again inhales deeply. There is no burning smell.

We return to the hallway area where Al looks above the ceiling again. A nurse observes that half of the EXIT sign is unlit—maybe that's the problem. The other nurses and orderlies standing idly by chuckle at her suggestion. Al moves his ladder to the sign and removes a plastic cover. Sure enough, it was a ballast in the EXIT sign that had literally burned out. It was a blackened coil of wire that reeked of the same smell we encountered when first arriving.⁷

Observing a skilled repair worker like Al in his element, it is hard to miss the role of his body: he uses it immediately to diagnose the source of the burning smell when he arrives on the scene, though it took a sharp visual observation from the nurse to help identify the particular light fixture causing the smell. Al's use of his nose as a tool of repair is an important form of materiality, a key means of connecting his body with the infrastructures that surround and structure his workplace. The skills and knowledge of an experienced mechanic may seem mysterious or even magical to those who observe or depend on repair, as their very embodiment can make it difficult for outsiders to observe how they operate. Embodied repair is paradoxically both visible and invisible: Al's embodied skill—and especially his nose!—were prominent in this episode, but his intuition about the source of the smell was buried in his nose and brain. Thus, the invisibility of infrastructures stems in part from bodily interactions with materiality, as we may not always observe or appreciate the hidden work and experience involved in infrastructural repair.

Another example of the embodied nature of repair work comes from Douglas Harper's book *Working Knowledge*, an ethnographic study that focuses on a mechanic named Willie who owns a small repair shop in rural New York where he fixes cars and farm equipment.⁸ Willie is an important person in his community due to his expertise in *bricolage*, or the art of using materials at hand in creative and skilled ways. For Willie's customers, paying cash for a new car or tractor part is often difficult, and so Willie is a master of fabricating and improvising solutions that are less costly and often more effective than replacing old parts. Harper emphasizes the importance of bodily knowledge for this work, as Willie must use craft knowledge of metalwork, welding, and reassembly to complete repairs.

In one part of the book, Harper focuses on Willie's expertise with automobile transmissions, noting that transmissions, purely mechanical devices, should be relatively straightforward to repair because they fit together in a manner governed by the logic of gears and illustrated through technical manuals. And yet: "Even in this most 'objective' of procedures it is the subtle play of force and pressure, the simultaneous movement of parts, and an evaluation of wear through the sensations of the fingertips that guide and control the process of work."⁹ At one point when discussing a particularly complex transmission, Willie describes the use of bodily sensations as a connection between hand and mind, where "it's just like your fingers got eyes."¹⁰ Similarly, one of the university mechanics Henke observed described an instrument for testing airflow as allowing him to "look" inside a duct.¹¹

While embodied knowledge is a key aspect of Willie's work, focusing just on his bodily skills tells only part of the story. Willie's use of his body in tandem with material objects and infrastructures means that while embodiment is clearly a key element of his repair work, his knowledge is also dependent on the specific context of the repair. Bodies may have what it takes to do repair work, but the work itself ties bodies together with a wider set of materials and discourses. Henke terms this body-in-context the *networked body*, "a body [that] has become situated within a larger setting of activity, rather than simply internalizing a previously external skill."¹² When Willie repairs a transmission, his ability to use his fingers and brain to feel his way through the problem is inherently tied up with the structure of the machine itself, making it hard to disentangle his knowledge from the materiality of the transmission and all its interlocking parts.

This view of embodiment helps us better understand repair in a few ways. First, the network model emphasizes the interconnectedness of diverse groups of people, technologies, and cultural meanings through infrastructures; our bodies get connected to each of these elements through experience and negotiation. Knowledge is not just in the body but distributed through the stuff of particular machines and systems. This leads to a second point about the time-dependent nature of bodily engagement with infrastructural networks. It takes time to understand infrastructures at the level of working knowledge and repair. Networks exist in particular times and places, meaning that while some repair skills might transfer to other contexts, some may not. Third, the networked body reorients the

relationship of the body, materiality, and repair, emphasizing that knowledge of infrastructures is not contained just in the bodies of repair workers; it is also embedded within a surrounding network of people and things. In the cold office problem, the office worker *knew in her body* what she perceived to be an abnormal temperature for her office space. While she may not have possessed working knowledge of her office's heating and ventilation system, her body had been networked into them enough that she felt something was wrong and needed to be fixed. This in turn made her an important element in the mechanic's network. Similarly, in the example of the burned light ballast in the hospital, a nurse was the first to notice and point to the fixture of her daily work environment that turned out to be the source of the trouble.

Summing up these points, the networked body helps us understand how we identify situations where repair is needed or necessary. The bodily sensation that something is locally wrong with infrastructures is frequently the genesis of repair, whether this sensation is experienced by a repair worker with intimate knowledge of a system or an everyday user who may not have deep understanding of the underlying problem. Repair, then, is a fundamentally experiential practice and sense of being, a form of awareness that comes from life lived in specific, local settings and in interaction with material systems and bodily sensations. Even when infrastructures are "inverted" and brought to the surface of our awareness through breakdown and trouble, we may not see how repair is applied to them, because the relationships of body, sensation, and structure are subtle and often themselves embedded within the networked body. Repair work is often described as invisible, but it may be more accurate to say that it is inscrutable in action—hard to discern because of the embodiment of infrastructural knowledge and repair skills.

Negotiating Discourses about Infrastructural Repair

This mix of bodies and objects, each providing a different point of view on the status of local systems, makes the study of repair a fruitful approach to understanding the negotiation of infrastructural order and change. In this section, we show this negotiation in more detail, especially the way that *discourse* about repair provides the social and material background for

everyday conversations about infrastructures. Discourse is commonly associated with talk and conversation, but social scientists use the term more broadly to include “an interrelated set of ‘story-lines’ which interprets the world around us and which becomes deeply embedded in societal institutions, agendas, and knowledge claims.”¹³ Discourse is dynamic in this view, with multiple discourses competing for relevance or becoming attached to particular situations. Discourses are a kind of cultural infrastructure in themselves, supporting how we think and talk about all kinds of things, including materiality. When we discuss and debate the status of infrastructures and the need for repair, discursive stories help us work out our relationships and problems with the material world. Control over stories can also provide a significant source of power for those who argue for one or another approach to repairing infrastructures, as we will see in chapter 3. Tracing discourses around repair is especially fruitful when disagreements occur. What happens when people tell different stories, with competing suggestions for repair or views on whether repair is required at all? Because infrastructure breakdowns create situations of disruption and unease, negotiations around repair may reveal competing narratives of what is wrong, who is at fault, and what should be done. This is where repair becomes a truly negotiated order, with participants giving competing accounts of trouble and what to do about it.

Once again, the cold office problem provides a useful set of examples. In the excerpt of an interview that follows, Henke asks Al, a specialist in heating, ventilation, and air-conditioning (HVAC) systems, to demonstrate some of the tools he commonly uses to do his work. Al describes his use of a tool called a hood flow meter to measure the airflow rate from a duct:

Al: [The flow meter] lets the customer know and see, that you’re doing something and that there is actually [laughing] air coming out . . . and you can actually show ‘em the reading. It seems to settle ‘em down a lot of times. You know that’s why in some of those labs you’ll see, just a little strip of paper taped off of [the vent]—for years they’ve been having problems and [saying], “I’m not getting any air!” [mocking customer]. You’ll hang that up there and take a reading and . . . let them see that there is air moving, and then you won’t get the same repeat calls again.

CRH: ‘Cause they can see for themselves.

Al: They can see yeah, and then they'll believe you. Where if you just go in and [hold] your hand [next to the vent] and go, "Yeah you're getting air out of here lady," they don't buy that, they wanna see something with some numbers flashing on it.¹⁴

Al describes his strategic use of the flow meter to nudge office workers back to a sense of normalcy, to prove via a technical display that air is flowing as it ought to be. Sociologists have noted that when we share a definition of reality in a given situation, we have a discourse for describing and thinking through the activities that make that reality happen.¹⁵ In this case, Al uses the readings from the flow meter to suggest that the customer is mistaken about the reality of the situation in her office and that she should trust the meter as an objective indicator of the truth of his definition of the situation.

Infrastructural Reality

Reality is reality, right?

Many infrastructures have a solidity based in their material form. Pipes and wires, concrete and steel—this is the stuff of a material reality that is hard to deny. And yet as we saw in the case of the cold office problem, two reasonable adults could quite easily disagree about the status of a particular infrastructure and the properties of a specific material environment, including whether the air was comfortable or not. Similarly, in the I-35W bridge example discussed in chapter 1, engineers did not "see" warped gusset plates as a sign of impending structural failure until after the bridge's collapse. Thinking about infrastructures as institutions can help us understand how they are flexible and solid at the same time.

In 1928, W. I. Thomas introduced a maxim that has since become a staple of introductory sociology courses: "if [humans] define situations as real, they are real in their consequences." Often described as the Thomas theorem, it is a simple yet profound insight into the power of social groups to effectively create their own reality. Shared "definitions of the situation" among human actors provide a basis for the most fundamental interactions, and when we do not share these common definitions, it can be hard to see things in the same way. Indeed, it is difficult to imagine collective social life without shared understandings like these, which allow us to take for granted many assumptions about how others in our culture see the world. At the same time, shared definitions of the situation can be oppressive when they marginalize people or groups on the basis of those assumptions. Racism is an example of a shared

definition used to support inequalities, constructed from a false view of biological difference.

A definition of the situation has immense consequences if it becomes institutionalized. Institutionalization is the process by which our shared definitions become embedded in structures such as laws, belief systems, and daily practices. While infrastructures are made of material stuff, they are also supported and embedded within a set of institutions that help us interact with them. Tracing the story of the I-35W bridge collapse very quickly connects that specific structure to a diverse set of economic, cultural, and political institutions that created the bridge and responded to its failure. In *The Social Construction of Reality*, Peter Berger and Thomas Luckmann describe the power of institutions to shape our reality and how, despite their basis in human definitions and work, institutions come to have a kind of “objectivity” that make them seem to exist outside human activity: “institutions . . . confront the individual as undeniable facts. The institutions are *there* . . . persistent in their reality, whether [the individual] likes it or not.”¹

The institutionalization of infrastructures explains their apparent solidity as much as or even more than their material structure, as our shared definitions and the power of institutions shape our view of infrastructures as taken-for-granted structures of everyday life when working in our favor and sources of frustration and fatalism when they seem beyond our control. When the temperature in an office is controlled by computers beyond an office worker’s authority, governed by HVAC algorithms developed by those with different definitions of the situation, it can seem that institutions and infrastructures are forces of their own will, outside an individual’s understanding or mastery.

Berger and Luckmann, however, also emphasize that institutions are fundamentally human creations, a reality of our own making: “the objectivity of the institutional world, however massive it may appear to the individual, is a humanly produced, constructed objectivity.”² Structures are very real, but their reality is one that we can and do shape every day.

1 Peter L. Berger and Thomas Luckmann, *The Social Construction of Reality: A Treatise in the Sociology of Knowledge* (Harmondsworth: Penguin, 1971), 57.

2 Berger and Luckmann, *The Social Construction of Reality*, 57.

AI and the other mechanics also use other technical data in this way, particularly data from sensors built into HVAC systems that measure the temperature of rooms, the status of the system, and other indicators, all of which can be accessed via a centralized computer terminal. In some cases, measurements point them toward the materiality of infrastructure systems. For example, after receiving another complaint about a cold room,

a technician named Henry went to the computer and found that the room temperature was 61 degrees Fahrenheit, and although the thermostat was set to a higher temperature, the room was not heating up. Henry promptly went to a valve hidden in the ceiling near this room and found that it had somehow been turned off. When he reopened the valve, the HVAC system brought the room back to the expected temperature.¹⁶

In other cases, where technical data and their intuition did not point straightforwardly to a faulty part, the mechanics diagnosed the human customers themselves as the problem in need of repair. The mechanics believed that weather conditions and the time of day were key factors influencing calls for repair, especially when someone believed that an office was too cold. For example, a cloudy day might make people feel colder, increasing the number of complaints about cold offices.¹⁷ This again highlights the human body as an indicator of infrastructure trouble.

In particular, the prominence of female bodies in these examples, such as the situation where Al uses the flow meter to show a “lady” that air is indeed coming into her office, points to the gendering of repair discourses. In fact, recent research on the history of HVAC engineering shows how heating and cooling profiles were developed based on male physiologies. Because of this, a gendered discourse of normal temperatures was built into the environments where many people live and work, which defined normal temperature in a way that privileged male bodies (see the “Defining and Controlling Thermal Comfort” box in this chapter).¹⁸ This privileging in turn created a situation that gendered HVAC repair work, based on assumptions about whose bodies are most appropriate for sensing and diagnosing the need for repair.

The social boundaries created by repair discourses can also be used to establish solidarity and community among repair workers. In his book *Talking about Machines*, Julian Orr describes his research with a group of Xerox photocopier repair technicians.¹⁹ Of particular interest are the “war stories” that the (largely male) technicians trade with each other, describing particularly troublesome or notorious repair situations.²⁰ These stories enable technicians to assert control over an unpredictable job that frequently involves negotiation and improvisation and to establish their masculine identities in opposition to management and customers. The stories serve more practical purposes as well, including the socialization of new technicians and the dissemination of new knowledge and tricks of the trade throughout

the repair community. Orr emphasizes that these narratives are no trivial matter, but rather an essential part of getting the work done.²¹ They help Xerox manage not only the material functionality of its products, but also the discursive frames that workers and customers use to understand those products and their repair. We return to this theme in more detail in coming chapters, but it is important to emphasize here the value that repair creates for organizations like Xerox. Repair workers not only maintain their products; the commitment to this work through war stories and identification with a set of working discourses makes repair more than just a job. Ultimately this discursive element of repair creates organizational value and corporate profit because workers see themselves as part of a heroic effort to keep systems in good working order.

Repair as Care: The Hot Airplane Problem

Imagine an airplane stuck on the runway, waiting for clearance from air traffic control before takeoff, in the midst of a busy summer holiday with many travelers. The plane waits in a long line of flights ready to depart, and the hot midday sun heats up the plane's cabin. A business traveler in first class presses a call button to summon a flight attendant and complains about feeling too warm. Air travel is one of our most complex infrastructures, merging many technical systems and institutions. At the moment of this interaction, however, the flight attendant is the point of repair for the overheated traveler. This scenario flips many of the features of the cold office problem: hot instead of cold, a moving space where both the air traveler and the flight attendant are only temporary residents, and, based on the fact that women make up a disproportionate number of workers in the service sector, including flight attendants, the likely gender identity of the person providing repair assistance.²²

The flight attendant might try to repair the traveler's discomfort in a material sense by helping adjust the vent above their seat, providing a cool drink, or talking to the pilot about changing the temperature settings for the cabin. She would also be expected to perform these actions with a smile and overall emotional affect meant to assuage the traveler and make them feel pampered and content. Just as in the cold office situation, this emotional work is integral to successful repair of the infrastructural problem. In sum, the flight attendant is required not only to resolve the material

problem, but to do so in a way that shows that she really cares for the overheated passenger.

The hot airplane problem illustrates the *care work* that a wide range of service workers provide as part of their jobs. Sociologist Arlie Hochschild, in her book *The Managed Heart*, describes this work as “emotional labor,” or the management of emotional display through face, gesture, and expression to convey a public demonstration of care.²³ Of course, many people engage in some kind of care work as part of their domestic and social relationships, but Hochschild emphasizes that performing care work as a condition of employment requires the “transmutation” of what we typically think of as private behaviors, performed in the context of close personal relationships, into work skills that are sold in exchange for a wage.²⁴ This has the effect of decoupling a worker’s internal emotional state from that person’s public affect. Even flight attendants who are irritated by the passenger or fatigued from working a long shift are expected to put on an apparently genuine “face” of care when promising to help the passenger.²⁵ While engineers and mechanics aren’t typically expected to display the overtly caring affect of a flight attendant or nurse, the cases discussed in this chapter suggest that emotional labor is an important, if often invisible, aspect of their repair practices as well. In the cold office problem, we saw how the work of Al and his colleagues was often as much about shaping the perceptions and feelings of customers as it was about tools and spare parts. This emotional labor is partly disguised by the fact that HVAC mechanics frequently use measurement tools and other technologies to shape the perceptions of customers; they also more often make use of an attitude of professional authority, rather than overt caring, to influence repair outcomes.

As Hochschild notes, however, emotional labor need not be associated with positive affect. Debt collection agents and parole officers, for example, are frequently required to engage in less positive emotional interactions with the people subject to their work. As we saw in the case of the cold office problem, negotiation between the repair person and the office worker involved a kind of back-and-forth discussion and perhaps even debate about the source of the trouble in question. A skilled repair person knows how to seamlessly integrate these affective interactions into an overall flow of repair work that also includes careful use of their body and the

tools and technologies at hand. Ultimately this way of seeing the world, as fragile and continually subject to the need for repair, is the basis for an “ethic of care,” as described in the writing of María Puig de la Bellacasa and other feminist scholars.²⁶ An ethic of care is often associated with the so-called caring professions such as nursing, primary education, and social services, domains of work that are traditionally gendered female in many cultures. As we have shown, however, even though mechanically focused repair work is not typically included among these professions, it does in fact require significant emotional labor and an ethic of care, but in this case focused more on things than people per se. The caring professions, too, are commonly tasked with troubleshooting breakdowns of social or material order, like illness or unemployment, further emphasizing their continuity with repair work, including the frequent association of repair with “dirty work.” Care work often involves direct work with bodies, chemicals, and other materials that may make the job literally messy, but also brings workers into complex situations where social and material order threaten to break down.²⁷

Willie, the rural mechanic, is a good example of a repair worker with a strong ethic of care for things. Harper’s ethnography emphasizes Willie’s work and how it matters within his local context, where the denizens of Willie’s community depend on him to fix their cars and tractors in a cost-effective manner. In so doing, Willie both cares for the community’s stock of machinery and plays a crucial role in enabling his customers and their families to maintain financial stability, given that they largely cannot afford to have their machines fixed at standard commercial rates. As a master bricoleur, Willie gains status in his community and a strong sense of his own identity as a skilled, caring repair worker and authority figure among his peers.

The notion that repair work is a kind of caring profession, akin to certain kinds of medical or social work, adds another layer to our understanding of the relationship between human bodies and infrastructures. For example, like HVAC mechanics, nurses perform technical services within a broader context of ensuring the well-being of people who are caught up in social structures that are beyond their control—in this case, the medical system, which is also a sort of infrastructure. In both professions, many workers observe an ethic of care that involves seeing the world as a fragile place

in need of constant monitoring and intervening in a compassionate manner to avert catastrophe or just human discomfort.²⁸ The commonalities between these professions again emphasize the way even our largest infrastructures and social institutions are ultimately grounded in human and material relationships at the local level, which are connected through the medium of the human body and the skills, knowledge, sensations, and emotions that reside there.

The Fragility of People and Things

A fragile item is not necessarily in need of repair, but nevertheless sits in a delicate state of existence, on the edge of stable and broken. Fragility calls our attention to the precarious state of material conditions, including the state of our own material bodies. A cautionary statement reading “FRAGILE” asks us to be care-ful, pointing to the connection between material states and our emotional orientations toward them.¹

In this chapter, we have emphasized the negotiated character of repair, where any sense of order that we experience in our infrastructural lives comes through the push and pull of people and things, mixed up in settings where they work out the contours of order and disorder. The fragility of these orders is highlighted in the work of STS scholars who question views of technology that emphasize settled states and fixed forms.² It seems strange to speak of an unstable stability, and yet that is the state of much materiality.

The fragility of infrastructures is no surprise to the repair workers who spend their days and years maintaining them, and Jérôme Denis and David Pontille emphasize this dual ontology through their research on the way-finding infrastructures of the Paris subway system.³ Signage is an important means of conceptualizing and navigating a complex urban system like a subway. Denis and Pontille locate the stability of signs in specific policies and standards that help to create a kind of organizational structure for signs and how to interpret them; standardized fonts, colors, and shapes provide consistency for both repair workers and subway users. At the same time, the maintenance workers charged with its repair dwell in a context where decay, vandalism, and even theft constantly shape the state of the signage infrastructure. Sometimes this decay is obvious to commuters or tourists making their way through the tunnels and trains, but other signs of fragility are visible only to the trained eyes of the maintenance workers, such as mold growing on a sign in a damp station near the Seine.⁴

Just as we described for the examples of Al and Willie, who used their bodies to diagnose and repair infrastructures, the subway maintenance staff

have a networked sense for the fragility of the signs, meaning that their work involves ongoing surveillance of the Parisian underground. Denis and Pontille describe this orientation as the “care of things,” a set of material and improvisatory practices that sees subtle degrees of brokenness in a particular local setting. Caring for things means always seeing them in a vulnerable condition, assessing and reassessing the need for repair.⁵ Fragility calls for care, and care points back to the important emotional component inherent in the repair of sociotechnical systems.

1 Benjamin Sims, “Safe Science: Material and Social Order in Laboratory Work,” *Social Studies of Science* 35, no. 3 (2005): 333–366.

2 Marianne de Laet and Annemarie Mol, “The Zimbabwe Bush Pump: Mechanics of a Fluid Technology,” *Social Studies of Science* 30, no. 2 (2000); Annemarie Mol, *The Logic of Care: Health and the Problem of Patient Choice* (New York: Routledge, 2008); John Law, “The Materials of STS,” in *The Oxford Handbook of Material Culture Studies* ed. Dan Hicks and Mary C. Beaudry (New York: Oxford University Press, 2010), 173–188; Jérôme Denis and David Pontille, “Maintenance Work and the Performativity of Urban Inscriptions: The Case of Paris Subway Signs,” *Environment and Planning D: Society and Space* 32, no. 3 (2014): 404–416; Jérôme Denis and David Pontille, “Material Ordering and the Care of Things,” *Science, Technology, and Human Values* 40, no. 3 (2015): 338–367.

3 Denis and Pontille, “Maintenance Work and the Performativity of Urban Inscriptions”; Denis and Pontille, “Material Ordering and the Care of Things.”

4 Denis and Pontille, “Material Ordering and the Care of Things,” 348–349.

5 Denis and Pontille, “Material Ordering and the Care of Things,” 348–349; Annemarie Mol, Ingunn Moser, and Jeanette Pols, “Care: Putting Practice into Theory,” in *Care in Practice: On Tinkering in Clinics, Homes, and Farms*, ed. Annemarie Mol, Ingunn Moser, and Jeanette Pols (Bielefeld, Germany: Transcript Verlag, 2010), 7–26; María Puig de la Bellacasa, “Matters of Care in Technoscience: Assembling Neglected Things,” *Social Studies of Science* 41, no. 1 (2011): 85–106; María Puig de la Bellacasa, “‘Nothing Comes without Its World’: Thinking with Care,” *Sociological Review* 60, no. 2 (2012): 197–216; Steven J. Jackson, “Rethinking Repair,” in *Media Technologies: Essays on Communication, Materiality and Society*, ed. Tarleton Gillespie, Pablo Boczkowski, and Kirsten Foot (Cambridge, MA: MIT Press, 2014), 221–239; Lara Houston and Steven J. Jackson, “Caring for the ‘Next Billion’ Mobile Handsets: Opening Proprietary Closures through the Work of Repair,” in *Proceedings of the Eighth International Conference on Information and Communication Technologies and Development* (New York: ACM, 2016), 10:1–10:11.

Conclusion: Local Communities of Repair

In this chapter, we have emphasized the role of discourse and negotiation in the work of repair, underscoring the ways repair creates the conditions for local infrastructures to remain relatively stable and invisible elements of our complex sociotechnical lives. Perhaps somewhat ironically, it takes a lot of local work to make something as ubiquitous as infrastructure invisible. More specifically, we have shown how infrastructure repair at a local level is not only accomplished through personal interactions and verbal negotiations between individuals, but is also closely tied to people's material bodies and the skills and sensations embodied within them. These bodies and their perceptions are embedded within local networks of people and things, which enable them to sense potential infrastructural breakdowns and provide access to the collective knowledge and resources required to repair them. Local networks are also the medium for repair work to serve as care work, maintaining and supporting the interpersonal and material elements and relationships that make up our sociotechnical systems. These local interactions are also the genesis of inequality in access to, and control over, infrastructure systems, as some bodies and perceptions are included in local networks and discourses and others become marginalized or even invisible. Indeed, these phenomena are all wrapped up together in some situations, where caring for people and things may actually lead to the invisibility and marginalization of repair workers.

The body, then, is the crossroads where the material and discursive elements of infrastructure and repair intersect. Part of the power of infrastructure lies in its role as a medium that both connects the human body to and buffers it from forces that can operate on a global, geophysical scale.²⁹ In this chapter, we have provided a detailed account of some of the specific, localized practices surrounding repair work that make this material connection between individual human bodies and global forces both possible and sustainable. To conclude, we explore how these connections can provide a context for community to develop around the practice of repair—in some cases, linking local sites for repair to broader, even global communities. The mediating technologies that increasingly connect our local bodies to global communications networks include consumer products such as cell phones and computers; indeed, technologies such as smartphones are more and more becoming extensions of our bodily senses, memories, and

knowledge.³⁰ But those same products break down—sometimes by design—and call into question the role of consumerism and corporate design methods in shaping these technologies' places in our lives.³¹ Research by repair scholars demonstrates these local-global dynamics through two key examples: repair collectives focused on supporting and empowering the users of broken technology to fix it themselves and cell phone repair technicians who draw on diverse resources to work on the devices that have become so integrated in human lives in many parts of the world.

Part of a broader “maker” movement fusing craft, art, and an ethos of sustainable reuse and recycling, repair collectives have emerged, especially in urban settings, at sites around the world. These collectives are often based around workshops where members work on their own projects as well as support those who come seeking assistance to repair a broken household item or to use a tool necessary to complete their own projects.³² These collectives are an important site for the creation of shared meanings and identities centered around repair. Just as the photocopier repair technicians spent considerable time “talking about machines” with their fellow workers, so collaborative repair settings for amateur fixers create a context for common ground, centered around material objects and their places within our daily rhythms. At the same time, fieldwork in these sites also reveals the ever-present influence of the same gender dynamics that we have described, where the relative value surrounding the work of male and female participants, their choice of projects, and the significance assigned to them are shaped through the gender politics of repair. Lara Houston, Daniela Rosner, and their colleagues describe a repair collective where many of the core participants are white men who have retired from the engineering profession, and in some cases dismiss or denigrate the projects that female attendees of the collective bring to them—this despite the avowed goal of the collective to support the transmission of repair skills and knowledge to new users, inviting new participants to actively engage in the hands-on process of repair.³³ In this way, the practice of repair is policed, and those seeking help may unwittingly “[confront] cultures of masculinity—and associated questions of visibility—developing in and around repair.”³⁴

As technologies such as internet chat rooms and streaming video services like YouTube allow those with repair needs and interests to communicate translocally, a kind of repair movement is emerging, struggling against the power of manufacturers to prevent consumers from repairing their own

products. This “right to repair” movement includes seemingly unlikely bed-fellows, such as farmers hacking into the computerized control systems on their high-tech tractors and websites, such as iFixit.com, showing owners of a smartphone with a broken screen how to repair it themselves (and selling them the parts to do it).³⁵

While these examples are focused more on the US context and consumers in industrialized nations, cell phones are among the fastest-growing consumer technologies in developing contexts, and their increasing ubiquity means that users must also maintain and repair their investment in the technology, though in some cases with fewer resources to discard broken or outdated units and upgrade to the newest models. Houston has conducted field research with repair technicians in Kampala, Uganda, to understand both the repair practices central to those who work on and maintain cell phones for users there, as well as their relationships with other repair practitioners both locally and via the internet.³⁶ These technicians are in some cases independent shop owners who do their work outside of the oversight and support of the major manufacturers, while other repair workers are attached to corporate retail outlets. Repair technicians who work for the major brands have access to tools and infrastructure that connect them with the manufacturers from afar; in some cases, these manufacturers even send their own representatives to set up the repair shops and put in place their own (proprietary) systems for phone repair.³⁷ Repair technicians who work in independent shops, however, have to rely on their own local, informal networks to share skills, tools, and practices when facing specific repair challenges. In some cases this involves consulting “peers located within walking distance” and, more distantly, “trans-local sites of repair knowledge online” via chat rooms and file-sharing websites.³⁸ This creates a community of repair practitioners forming its own “infrastructures of repair . . . actively pieced together by technicians in the work of searching, connecting and collaborating” to find effective fixes.³⁹ This community grows from the specific market for phones in Uganda, where many of the cell phones that independent technicians repair are recycled units that are imported from industrialized nations and have a second life with users in locations where the market for these phones helps to satisfy demand for cheaper models.

Hacking into the software on the phone is required to open up the phones for use on Ugandan networks, and the repair technicians can

find the tools they need through online file-sharing services and creative engineering of specialized tools that allow reprogramming of the phones. Limits on the formation of these communities of repair workers and entrepreneurs, however, come from two sources: competition among rival repair groups promoting the use of their own hacks and products, as well as from limitations imposed by the manufacturers themselves. Similar to the case of an American farmer struggling to fix their own tractor, however, the independent technicians in Kampala are also subject to systems of control implemented by the manufacturers, such as SIM card locks that prevent technicians from accessing and repairing phones with these systems.⁴⁰

In the cases of repair collectives and communities of cell phone repair technicians in developing contexts, we see examples of the potential for repair to create new networks and identities around the technologies and infrastructures for communication enabled by a complex mix of consumer electronics and global networks of exchange. These local communities have the potential to influence broader values and even new institutions. Sociologist Gary Alan Fine argues that “tiny publics” such as local associations and networks make a difference at a larger social scale because their ways of doing things bubble up into collective identities and beliefs that shape larger social structures and forms of order.⁴¹ The right-to-repair movement is one such example of how repair might bring together coalitions of interests to influence cultural and legal change at a national or even international level. Given the scale of large infrastructural systems, their scope can potentially dissuade attempts to change their structure and politics, but the way that users engage locally with technology provides a potential site for intervention and change. At the same time, the examples in this section point to the continued power of corporate interests in shaping our uses—including the preclusion of unwanted uses—as well as potential conflict among users with competing interests and identities invested in repair. Local bodies and materiality connect with these diverse infrastructural elements through time and space. The coming chapters continue to explore how repair is negotiated at scales that link the local to regional, national, and global networks.

